

body 1 that defines the open top, so as to seal off the chamber, e.g., render it airtight.

**[0016]** Inside the chamber or chamber body 1 is a plate 5 whose bottom face may rest upon the substance. The plate 5 has a heater 6 therein that releases heat directly above the substance that is below it. The plate 5 is sized and shaped such that it can slide downward within the chamber as the substance is consumed by vaporization or sublimation, but may be large enough in area to cover as much of the top surface of the substance as possible. In one embodiment, the outermost edge of the plate 5 extends to and is shaped to conform to the inner surface of the sidewall 2 of the chamber body 1 (e.g. as a circle), while allowing the plate 5 to slide downward within the chamber body (as the substance is vaporized or sublimated). In this manner, heat released from the plate 5 may efficiently supplement at least part of the energy that is lost through cooling along virtually the entire surface of the substance (latent heat vaporization.) This takes place continuously while the substance is consumed, to render an efficient vaporization/sublimation process.

**[0017]** In one embodiment, there may be enough pressure developed within a gap between the top surface of the substance and the bottom face of the plate 5 such that the plate 5 may lift slightly above the substance. Thus, although the plate 5 is described as initially resting on the substance so that it may tap the top surface of the substance flat, it may also “float” during vaporization or sublimation.

**[0018]** Although not shown in FIG. 1, any suitable technique may be used to draw out the vapor (e.g., as a mixture together with a carrier gas) from the chamber, depending upon certain factors including the vapor pressure of the substance. For example, an outlet hole 12 may be formed in the lid 4 (not shown in FIG. 1, but see the embodiment of FIG. 3 described below) through which the vapor is drawn out of the chamber. Although not shown, a mist or solid separator may be present at the outlet hole 12, to prevent the formation of any solid that could block the outlet hole 12.

**[0019]** Turning now to FIG. 2, this is an exploded view of an example embodiment of the apparatus for vaporization or sublimation of a substance. Several mechanisms are shown that may assist in providing an isothermal condition for the vaporization/sublimation process. First, a thermal jacket 8 may surround the chamber body 1 (see also FIG. 3 which shows the thermal jacket 8 in place.) The thermal jacket 8 helps maintain an isothermal condition by releasing heat into the adjacent sidewall 2 of the chamber body 1. The thermal jacket 8 may have an internal passage 17 therein—see FIG. 3—through which thermal fluid is to circulate during the process. In one embodiment, the passage 17 forms a spiraling channel that spirals and surrounds the sidewall 2 and may extend the full height, in a vertical direction, as shown, of the chamber body 1. Thermal fluid circulates within the passage 17, e.g., through plumbing and propelled by a pump that are not shown, in order to raise the temperature of the chamber body 1 to help achieve vaporization or sublimation of the substance, and maintain an isothermal condition. The thermal jacket 8 and its internal thermal fluid passage 17 may also extend across the bottom 3 of the chamber body 1 to further help maintain the isothermal condition across the entirety of the chamber body 1. The thermal fluid may be temperature-controlled to help maintain a consistent vaporization/sublimation process temperature (as the rate of vaporization/sublimation may depend on the temperature).

**[0020]** Another aspect that is shown in FIG. 2 is a lid assembly 9 that is composed of the lid 4 to which the plate 5 is connected through inlet tubing 14 and outlet tubing 12. A thermal fluid sourced from outside of the canister is to circulate through the inlet tubing 14, into a passage 13 in the heater 6 within the plate 5—see FIG. 3—and then out through the outlet tubing 12. This is an embodiment in which the heater 6 is a radiant heater. A recirculation unit and fluid heater may be provided outside of the chamber body 1 that is coupled to the inlet and outlet tubings 14, 12 via respective ports formed in the lid 4, to regulate the flow of the thermal fluid that is circulating so as to maintain an isothermal condition within the chamber body 1, and especially within the boundary region that is between the top of the substance and the bottom face of the plate 5. As seen in FIG. 3, a thermal fluid passage 11 may also be formed in the lid 4 that may serve to more efficiently transfer heat to the lid 4, by circulating the thermal fluid throughout the lid 4 prior to the fluid then exiting the lid and passing into the inlet tubing 14.

**[0021]** In one embodiment, the lid 4 has a fluid inlet port that is connected to an upper end (inlet) of the inlet tubing 14, while a lower end (outlet) of the inlet tubing 14 is connected to an inlet of the internal fluid passage 13 that is formed in the plate 5. Similarly, outlet tubing 14 has an upper end (outlet) that is connected to a fluid outlet port in the lid 4, and a lower end (inlet) that is connected to an outlet of the internal fluid passage 13 formed in the plate 5. This enables the thermal fluid to be circulated as follows: into the canister through an inlet port or orifice in the lid 4 (not shown), through the passage 11 in the lid 4, and then out of the lid 4 and into the inlet tubing 14, and then into the passage 13 where it circulates through the plate 5, and then exits the plate 5 and passes into the outlet tubing 12, and then out of the canister through an outlet port or orifices in the lid 4 (not shown). The inlet tubing 14 thus brings a heat transfer or thermal fluid from the lid 4 down into the passage 13 that is formed within the plate 5, which by virtue of heat transfer thus acts as the heater 6 which is across the top surface of the substance being sublimated or vaporized (see FIG. 1). The thermal fluid is returned to the lid 4 through the outlet tubing 14.

**[0022]** The inlet tubing 14 and the outlet tubing 12 may each be structured, as also shown in FIG. 5, as coiled tubing or a coil that fits inside the chamber. The coiled tubing or coil is compressed or shortened initially (before the substance is consumed by vaporization or sublimation), but then expands (lengthens) as the plate 5 slides downward due to the substance being consumed. That occurs because the plate 5 is attached to and therefore pulls down on the lower ends of the inlet and outlet tubing 14, 12, e.g. due to gravity alone, as the substance is consumed. In this manner, circulation of the thermal fluid through the heater 6 of the plate 5 is maintained continuously during the vaporization/sublimation process.

**[0023]** Note, however, that in other embodiments, the heater 6 may be different than a thermal fluid radiator. For example, the heater 6 may be an infrared lamp, a resistive device heater, or an inductive element heater. In such instances, there may be no need for the inlet and outlet tubing 14, 12 since there is no thermal fluid that is being circulated through the plate 5.

**[0024]** Returning to the embodiments shown in FIG. 2 and FIG. 3, where tubing 12, 14 may be attached to the lid 4 (to form a lid assembly 9) and that serves to heat the plate 5, it